REPRODUCTION AND GROWTH IN CAPTIVE DEATH ADDERS *ACANTHOPHIS ANTARCTICUS* (SQUAMATA: ELAPIDAE)

A captive colony of *Acanthophis antarcticus* has been maintained at Whyalla, South Australia since 1975. Several papers have described the birth of individual clutches into the colony[1,2,3]. Mirtschin has outlined the maintenance schedule for the colony[4] and the release of death adders bred at Whyalla[5]. This paper presents new data on the biology of *A. antarcticus* kept at Whyalla, including seasonality of mating and births, primary sex ratio, clutch size, caudal luring, growth and maturity.

Adult snakes were collected from Iron Duke (33°18'S, 137°08'E), Port Germein (33°01'S, 138°00 E), Tumby Bay (34°23'S, 136°06'E) and Ardrossan (34°25'S, 37°54'E). They were housed in enclosures described by Mirtschin[4] at temperatures of 27–30°C and fed entirely on house mice (*Mus musculus*) and rats (*Rattus norvegicus*). Neonates accepted pink mice. Snakes were fed older, larger mice or rats commensurate with increasing body size and their ability to consume larger food items.

Dates of mating and births have been recorded from the foundation of the colony. Weight (gm) using a Mettler top-loading balance and total length (cm) using a centimetre rule were measured for snakes in the colony of known age in February, June, August and December 1982. Snakes were measured and weighed from clutches born in 1979, 1981 and 1982. Primary sex ratios were determined by probing[6] for seven clutches born between January 1982 and April 1983 (Table 1). Clutch size was determined for 14 clutches born between February 1976 and April 1983.

Length and weight against time and length against weight were examined by least-squares regression[7]. Linear ($Y = a + bX$), exponential ($\ln Y = a + bX$), logarithmic ($Y = a + b\ln X$) and power ($\ln Y = a + b\ln X$) equations were used to find the best fit to the data, where Y = the dependent variable, X = the independent variable, a = the y-intercept and b = the slope of the fitted line. For each regression the coefficient of determination (R^2) was used as the criterion for which equation best fit a given set of data. Data were treated without regard to sex.

The *A. antarcticus* reported here show an annual reproductive cycle[9], mating shortly after winter brumation and giving birth before brumation the following year. Mating was observed 24 times prior to March 1983 and fourteen clutches totalling 285 neonates were born into the colony during the same period (Fig. 1, Table 1). Mating was at its height in October and births peaked in February and March. Gestation takes four-five months over summer. Minor mating activity occurs shortly after parturition.

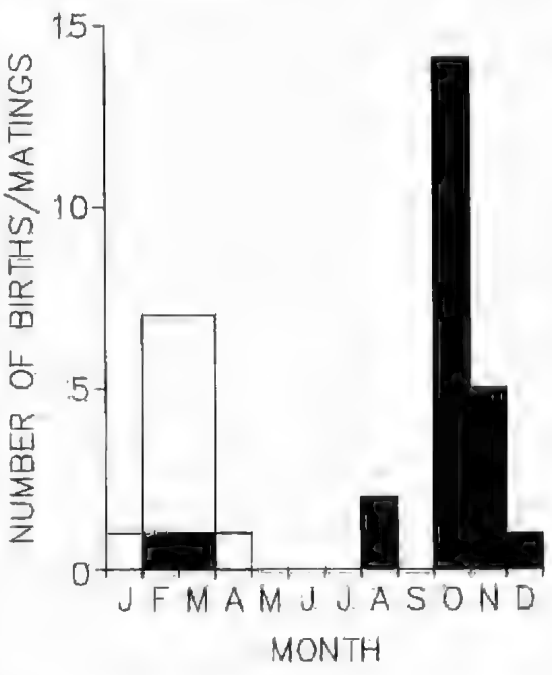

Fig. 1. Monthly occurrence of births (open bars) and matings (solid bars) recorded in *A. antarcticus* at the Whyalla Fauna Park, South Australia between 1976 and 1983.

TABLE 1. *Dates of birth, sex ratios and clutch sizes for death adder clutches born in captivity at Whyalla.*

Clutch	Date	male	female	unsexed	total
1	10.iii.1976	—	—	—	24
2	20.iii.1976	—	—	—	19
3	13.iii.1977	—	—	—	10
4	10.iii.1979	—	—	—	24
5	28.i.1981	—	—	—	11
6	3.ii.1981	—	—	—	18
7	6.ii.1982	7	8	2	17
8	10.ii.1982	12	15	—	27
9	10.ii.1983	7	17	—	24
10	10.ii.1983	5	11	—	16
11	11.ii.1983	16	17	—	33
12	21.ii.1983	7	14	—	21
13	1.iii.1983	8	17	—	25
14	22.iii.1983	9	7	—	16

Mating has been reported previously for *A. antarcticus* in January-April[10,11], and August-December[2,10]. Shine[12] found that ovulation takes place in late spring to early summer and embryos were present in females collected between December and March. Males were in reproductive condition throughout the year.

One female *A. antarcticus* born in 1980 is known to have produced clutches in four successive years. Hay & Magnusson[10] reported a female who bore clutches for three years in succession. However, Shine[12] found that approximately 50% of wild adult females were not in reproductive condition over the summer months and concluded they show reproductive asynchrony such that individuals reproduce biannually but the population reproduces each year. Discrepancies between annual reproductive cycles reported for captive death adders and biennial cycles in the field are probably due to a shift in the relative adaptive value of low frequencies of

reproduction in captive versus field conditions[13]. Food availability and low thermal stress may be prime factors involved here.

The mean primary sex ratio differed significantly from expected[8], with females outnumbering males (X^2[df = 1] = 44.032, $P<0.001$), although there was considerable variation between clutches (Table 1). Hay & Magnusson[10] have also noted a significant bias toward females in death adders. The variation from expected sex ratio cannot be explained by differential reproductive investments by females to hatchlings of each sex. Twenty seven female neonates from clutches 7 & 8 (Table 1) measured within 24 hrs of parturition were significantly heavier ($\bar{x}$ = 5.84, SD = 0.426 gm, range = 5.22–6.65) than 15 males from the same clutches ($\bar{x}$ = 5.09, SD = 0.269, range = 4.38–5.54) (t[df = 40] = 6.499, $p<0.001$). Data contained in Shine's[12] table 1 show a significantly higher number of adult males than adult females in wild populations (X^2[df = 1] = 4.300, $P<0.05$). As elapids have heteromorphic sex chromosomes[14] it is probable that sex determination in *A. antarcticus* is genetically controlled[15]. It is interesting to note that the sex ratio bias reverses between captive neonates and wild adults, indicating differential mortality between the sexes in wild populations.

Clutch sizes of 2–24 have been reported previously for *A. antarcticus*[10,12]. The captive clutch sizes reported here (Table 1) ($\bar{x}$ = 20.4, SD = 6.31) and by Hay & Magnusson[10] (x = 20.8, SD = 2.30, N = 12) are considerably larger than those reported for clutches in the field ($\bar{x}$ = 7.9)[12].

Neonates have been observed on several occasions caudal luring immediately post-parturition. This indicates that caudal luring is an innate behaviour and not learned. Heatwole & Davison[16] found that most species which exhibit caudal luring do so only as juveniles. Adult death adders in the Whyalla colony have always been observed to wriggle their tails vigorously whenever an enclosure is approached and especially when a food item is placed in the enclosure. Carpenter, Murphy & Carpenter also have reported adult *Acanthophis* caudal luring[17].

At parturition neonates averaged 15.85 cm (SD = 1.20) in total length and 5.93 gm (SD = 1.09) in weight. Growth by weight was best described by the exponential equation:

$$\ln W = 1.822 + 0.123T$$

where W = weight (gm) and T = age (mo) (Fig. 2). Correlation coefficients (r) were significantly different between exponential and logarithmic models ($P<0.001$)[18] but linear and power models were similar to the exponential model ($P's>0.05$) (Table 2). Growth by total length was best described by the linear equation:

$$L = 15.907 + 1.211T$$

where T is as above, and L = length (cm) (Fig. 3). Correlation coefficients of exponential and logarithmic models where significantly different from the linear model ($P's<0.001$) but the power model was similar ($P>0.5$) (Table 2). The relationship between weight and total length is given by the power equation:

$$\ln W = -6.761 + 3.085\ln L$$

where W and L are as above. Correlation coefficients for the linear, logarithmic and exponential models were all

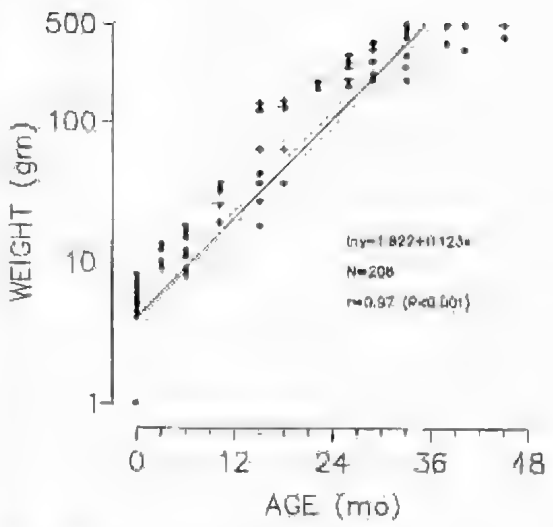

Fig. 2. Growth by weight (gm) of captive *A. antarcticus* over a four year period. Each symbol may represent more than one data point.

significantly different from the power model ($P's<0.005$) (Table 2, Fig. 4).

In the field newborn *A. antarcticus* appear in autumn measuring 12 cm snout-vent length and grow to 20 cm by the end of the calendar year and 30 cm by 21 mo[12]. This curve considerably underestimates the curve reported here over that time period for captive animals, but it does predict actual fourth year size accurately if extended on at the same gradient. The results reported here may be taken as an optimum curve for captive death adders. The initial difference in the growth curves may be because juvenile death adders at Whyalla are fed mice and wild populations take mostly reptiles in younger life[7].

Wild *A. antarcticus* do not reach sexual maturity until 24 and 42 mo for males and females, respectively[7].

TABLE 2. *Comparison of regression equations for growth on weight, growth on total length and weight on total length in captive death adders at Whyalla.*

Equation	R^2
Weight vs Age	
W = 4.009 + 9.434T	0.869
W = 230.233 + 147.134lnT	0.682
lnW = 1.822 + 0.123T	0.942
lnW = 0.217 + 1.533lnT	0.885
Length vs Age	
L = 15.907 + 1.211T	0.941
L = −4.067 + 16.330lnT	0.811
lnL = 2.789 + 0.039T	0.923
lnL = 2.356 + 0.462lnT	0.893
Weight vs Length	
W = −121.041 + 7.499L	0.855
W = −613.020 + 220.401lnL	0.770
lnW = 0.286 + 0.098L	0.939
lnW = −6.761 + 3.085lnL	0.966

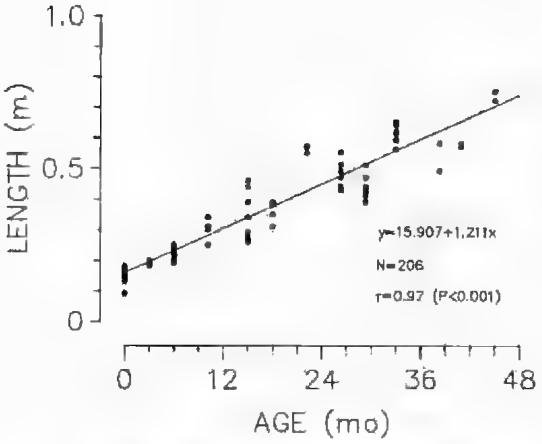

Fig. 3. Growth by length (cm) of captive *A. antarcticus* over a four year period. Each symbol may represent more than one data point.

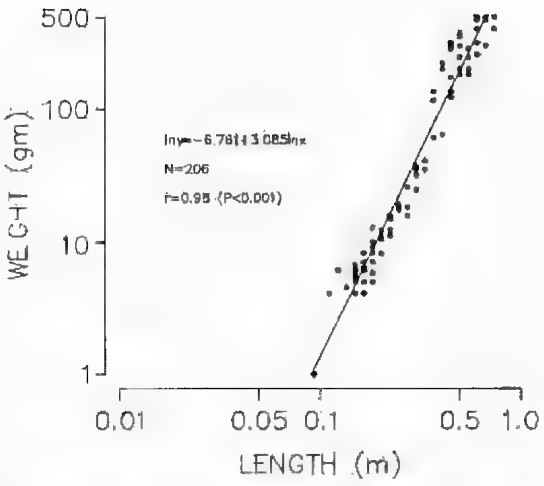

Fig. 4. Relationship between weight (gm) and length (cm) in captive *A. antarcticus*. Each symbol may represent more than one data point.

Newly mature females measure approximately 30 cm in length and males 44 cm[7]. In captivity these lengths may be reached in ten and fifteen months, respectively. Hay & Magnusson's death adders matured at similar ages to wild populations[10]. Maturity is generally related to size rather than age in reptiles[19,20]. This would explain why some specimens held at Whyalla have been observed mating at 19 mo[3].

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PARATACAMITE FROM SOUTH AUSTRALIA

Summary